

THE PHOSPHORUS INDEX

South Carolina

Introduction

The Phosphorus Index (PI) is a site specific, qualitative vulnerability assessment tool. This tool allows a conservation planner to determine, from among a series of proposed phosphorus (P) application sites, which sites are potentially most vulnerable to the off-site movement of P. These sites based on this information should then be considered for more careful management of phosphorus.

USDA, Natural Resources Conservation Service (NRCS) policy for nutrient management, identified the PI as a technique which offers the greatest amount of flexibility for making P application and management decisions for nutrient management. In this policy, the PI is used to determine when animal by-products, primarily manure utilization, may be based on a nitrogen-based budget and when such utilization must be based on a P-based budget. The policy also stresses the use of this tool in any designated P limited areas.

This Phosphorus Index was developed by the USDA-NRCS in South Carolina with the cooperation of the Clemson University (CU), Cooperative Extension Service (CES).

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Name _____ Tract _____ Field _____ Crop _____ County _____

Assisted by _____ Checked by _____ Date _____

Field Features and Management Practices	Phosphorus source factor [Value]					Value
Soil test P (lbs-P/acre)	Soil Test P x 0.10					
Fertilizer P rate or Organic P source (manure) application rate (lbs-P ₂ O ₅ /acre)	P ₂ O ₅ application rate x 0.25 x Application Method Coefficient [_____] x 0.25 x [_____]					
	Application Method Coefficient					
Application method for fertilizer and/or organic source	None [0]	Injected into the soil 2 inches or deeper [0.25]	Incorporated within one day of application or prior to rainfall/irrigation [0.5]	Surface applied 30 days or less before crop [1.0]		
	Total P Loss Source Potential Factor (subtotal)					
	Phosphorus transport factor [Value]					Value
Soil erosion (tons/acre)	< 1 [0.01]	1 – 5 [0.05]	6 – 10 [0.1]	11 – 15 [0.2]	> 15 [0.4]	
Runoff Factor	Negligible or Very Low [0]	Low [0.05]	Medium [0.1]	High [0.2]	Very High [0.4]	
Subsurface Drainage Factor	Very Low [0]	Low [0.05]	Medium [0.1]	High [0.2]	Very High [0.4]	
	Total P Loss Transport Potential Factor (subtotal)					
	Buffer / Setback Zones (No P application Zone) [Value]					Value
Distance to water body (feet)	>100 [0.25]	76 – 100 [0.30]	51 – 75 [0.35]	26 – 50 [0.40]	15 – 25 [0.45]	< 15 [0.50]
Buffer Zone (no P application zone) Runoff Class	Negligible [0.25]	Very Low [0.30]	Low [0.35]	Medium [0.40]	High [0.45]	Very High [0.50]
	Total Buffer / Setback Zone Reduction Factor (subtotal)					

Σ(Source Potential Factors)	
X Σ(Transport Potential Factors)	
X Σ(Buffer / Setback Reduction Factor)	
= P index rating	

Site Vulnerability	Total Index Rating Value
PI-1	< 6
PI-2	6 – 10
PI-3	11 – 25
PI-4	> 25

Interpreting the PI Rating

Use the following chart to explain the individual PI rating classes. It is important to understand that the PI rating does not have a numeric meaning. It has only a relative meaning. Those fields in the “PI-1” category are predicted to have a relatively lower potential for P losses than those fields in the “PI-2” PI rating category. Those fields in the “PI-2” PI rating category are predicted to have a relatively lower potential for P losses than those fields in the “PI-3” PI rating category, and so on.

P Index Rating	Generalized Interpretation of PI Rating
≤ 6	PI-1: low potential for P movement from this site given current management practices and site characteristics. There is a low probability of an adverse impact to surface waters from P losses from this site. Nitrogen (N) -based nutrient management planning is satisfactory for this site. Soil P levels and P loss potential may increase in the future due to N-based nutrient management of animal manures.
$\geq 6 - 10$	PI-2: medium potential for P movement from this site given current management practices and site characteristics. Practices should be implemented to reduce P losses by surface runoff, subsurface flow, and erosion. Phosphorus applications should be limited to the two (2) times the amount expected to be removed from the field by crop harvest. However, if the application rate of two times the phosphorus removal exceeds the recommended nitrogen rate, application should be limited to the nitrogen rate.
11 – 25	PI-3: high potential for P movement from this site given current management practices and site characteristics. P-based nutrient management planning should be used for this site. Phosphorus applications should be limited to crop uptake and removal of phosphorus (P) or the recommended P application as given by the Clemson University, whichever is greater. All practical management practices for reducing P losses by surface runoff, subsurface flow, or erosion should be implemented.
> 25	PI-4: very high potential for P movement from this site given current management practices and site characteristics. No P should be applied to this site. Active remediation techniques should be implemented in an effort to reduce the P loss potential from this site.

Phosphorus Index Notes: Information to support the determination of the PI

Name _____ Tract _____ Field _____ County _____

Assisted by _____ Checked by _____ Date _____

Step 1. Gather all appropriate information

Farm Operator	
Soil test P	
Amount and type of fertilizer used	
Application method	
Type and width of buffers (width = distance of the no P application zone)	
Crop rotation	
Special conservation practices	
Soil Survey	
Predominant Soil type	
Soil drainage class	
Depth to seasonal high water table	
RUSLE2	
R	
K	
LS	
C	
P	
EFM-2 / TR-55	
Runoff curve number for field	
Runoff curve number for buffer zone	
Field visit	
Distance to surface water (width of no P application zone)	
Slope: Length Steepness	
Tile drainage	

Step 2. Determine the field value for each factor

P Source Potential	PI Value
Soil Test P	
P application rate and application method	
Total P source potential characteristics value (sum of above factors)	
P Transport Potential	PI multiplication value
Soil Erosion	
Runoff Class	
Subsurface Drainage Factor	
Total P transport potential characteristics value (sum of above factors)	
Buffer / Setback Zone Factor	PI multiplication value
Distance to water body	
Buffer Zone Runoff Class	
Total buffer / setback characteristics value (sum of above factors)	

Step 3. Determine PI Rating

Σ (Source Potential Factor)	
* Σ (Transport Potential Factor)	
* Σ (Buffer / Setback Reduction Factor)	
= PI Rating	

STEP 1

Gather all appropriate information

The following is a complete list of all of the required information, along with where that information is found. Most of this information will not be direct factors in the Index, but will be used to determine PI values.

Source	Item
Farm Operator	soil test P (Mehlich I method)
Farm Operator	amount and type of P fertilizer applied
Farm Operator	application method for P fertilizer
Farm Operator	type and width of buffers and/or no P application zone
Farm Operator	crop rotation including tillage
Farm Operator	special practices such as strip or contour cropping
EFM - 2 or TR – 55	NRCS curve number
Soil Survey	predominant soil type in field. Determined by choosing the predominant soil type from the soil survey. If the predominancy is difficult to determine, use best judgement to choose the soil which best represents the field.
Soil Survey	subsurface drainage class
Soil Survey	depth to seasonal high water table (feet)
Field Visit	distance to surface water
Field Visit	slope of field (includes field and slope length), usually measured with a clinometer
Field Visit	tile/mole/artificial subsurface drainage (yes or no)
Field Visit	RUSLE2“P” practices - hydrologic soil group (found in FOTG, Engineering Interpretations, Water Features), ridge height, furrow grade, cover management condition

What you will need:

local soil survey
soil test report
RUSLE2 handbook

clinometer
EFM 2 / TR 55
P Index packet

measuring tape
calculator

STEP 2

Determine the value for each factor

After the basic information has been collected, this information is used to determine the value for each factor. The P Site Index is divided into **Source Potential characteristics and Transport Potential characteristics for each land application field.**

Phosphorus Loss Potential Source Factor

1. Soil Test P

Soil test P must be expressed in (lbs. P / acre) using the Mehlich I laboratory procedure as used by Clemson University. This will insure that all comparisons of soil test P are comparable. Waters Laboratory uses the Mehlich I procedure, while A&L Laboratory and North Carolina State University use the Mehlich III procedure. A Mehlich III values may be converted to Mehlich I using the following conversion: Mehlich III = 1.5(Mehlich I)

Soil Test P (lb P / acre) x 0.10 = [input value for index rating]

2. P Application Rate Factor (Fertilizer or Organic Source)

The P application rate factor is determined by both the actual application rate and by the application method. This factor is the same for P from a fertilizer source and an organic source. The rate intended to be applied to the field is the rate that should be used. Typically, the nitrogen (N)-based application rate would be used in the initial assessment of the PI. The N-based application rate usually provides the maximum amount of P that will be applied to a field (i.e. the worst case scenario). Assessments using other rates of application, such as the minimum amounts that can be distributed with available application equipment may be desirable. Also, application rates may differ with split application of nutrients.

The factor is calculated as follows.

P₂O₅ application rate (lb P₂O₅ / acre) x 0.25 x Application Method Coefficient = [Index Input Value]

Application Method Coefficient	Value
None applied	0
Placed or injected deeper than 2 inches	0.25
Incorporated immediately before crop	0.5
Surface applied 30 days or less before crop	1.0

Phosphorus Loss Potential Transport Factor

1. Soil Erosion: RUSLE2 (Revised Universal Soil Loss Equation 2)

RUSLE2 is a computer model containing both empirical and process-based science that predicts rill and interrill erosion by rainfall and runoff. The program, databases, instructions, tutorials and other documentation are available at

http://fargo.nserl.purdue.edu/rusle2_dataweb/RUSLE2_Index.htm.

Field Surface Runoff Factor

Soil Runoff Factor is determined from the following chart based on the slope of the field and the runoff curve number. The runoff curve number should be determined using the method in the NRCS Engineering Field Handbook – Chapter 2 or Technical Release 55, Hydrology for Urban Watersheds (<http://www.wcc.nrcs.usda.gov/water/quality/common/tr55/tr55.pdf>). Predominant land slope for surface runoff shall be determined during a site visit.

	Runoff Curve Number				
Slope (%)	< 50	50 - 60	60 - 70	70 - 80	> 80
	RUNOFF FACTOR				
< 1	N	N	N	N	M
1 – 2	N	N	VL	L	M
2 – 4	N	N	VL	M	H
4 – 8	N	VL	M	H	VH
8 – 16	VL	L	M	VH	VH
> 16	VL	L	H	VH	VH

N = negligible
M = medium

VL = very low
H = high

L = low
VH = very high

Move down the left column to find the slope that was determined in the field. Move across the top row to find the range containing the computed runoff curve number. Where the selected column and row intersect in the chart determines the soil runoff factor value.

Runoff Class	N or VL	L	M	H	VH
Value	0	0.05	0.10	0.20	0.40

3. Subsurface Drainage Factor

The subsurface drainage factor is determined from the following chart:

Depth to Seasonal High Water Table (feet)	Subsoil Permeability					
	Very slow (0.06-0.2 in/hr)	slow (0.2 -0.6 in/hr)	moderately slow (0.6-2.0 in/hr)	moderate (2.0-6.0 in/hr)	rapid (6-20 in/hr)	very rapid (> 20 in/hr)
0 – 1	H	VH	VH	VH	VH	VH
1 – 3	M	M	M	H	H	VH
3 – 6	L	L	L	M	M	H
> 6	VL	VL	L	L	L	M
Artificial Subsurface Drainage (any depth) or Subsurface drainage via field ditches	H	H	H	H	H	H

VL = very low
H = high

L = low
VH = very high

M = medium

Move down the left column to find the seasonal high water table depth found in the soil survey. Then move across the top row to find the soil drainage class found in the soil survey. Where the selected column and row intersect in the chart determines the subsurface drainage class value. ALSO, it is important to note that any artificial subsurface drainage (tile drains, mole drains) will automatically give the field a HIGH subsurface drainage class value (bottom row of chart).

Subsurface Drainage Factor	VL	L	M	H	VH
Value	0	0.05	0.10	0.20	0.40

Buffer / Setback Zones (No P Application zone)

1. Distance from edge of the *P application zone* to surface water (width of the Buffer Zone)

The buffer zone width is actually the distance from the edge of the P application zone (this may or may not be at the edge of a field) to a surface water body. Surface water includes any permanent conduit for transporting surface water, including permanent streams and ditches that flow intermittently through the year. Also, drain tile with surface inlets that discharge into a ditch or a stream should be treated as a surface water body.

Width of the Buffer Zone or Distance from the Edge of the <i>no P application zone</i> to a Surface Water Body [lakes, ponds, streams (perennial and intermittent), and ditches that lead directly to a water of the State]	Value
> 100 feet	0.25
76 to 100 feet	0.30
51 to 75 feet	0.35
26 to 50 feet	0.40
15 to 25 feet	0.45
< 15 feet	0.50

2. Buffer Surface Water Runoff Class

The Surface Water Runoff Class for the Buffer Zone is determined from the following chart based on the slope of the field buffer area and the runoff curve number of the buffer zone. The runoff curve number should be computed using the method in the NRCS Engineering Field Handbook – Chapter 2 or Technical Release 55, Hydrology for Urban Watersheds (<http://www.wcc.nrcs.usda.gov/water/quality/common/tr55/tr55.pdf>). Predominant land slope shall be determined during a site visit.

	Runoff Curve Number				
Slope (%)	< 50	50 – 60	60 - 70	70 - 80	> 80
	RUNOFF CLASS				
< 1	N	N	N	N	M
1 – 2	N	N	VL	L	M
2 – 4	N	N	VL	M	H
4 – 8	N	VL	M	H	VH
8 – 16	VL	L	M	VH	VH
>16	VL	L	H	VH	VH

N = negligible
M = medium

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Move down the left column to find the slope that was determined in the field. Move across the top row to find the range containing the computed runoff curve number. Where the selected column and row intersect in the chart determines the soil runoff class value.

Runoff Class	N	VL	L	M	H	VH
Value	0.25	0.30	0.35	0.40	0.45	0.5

STEP 3

Determine the PI

Multiply the sum of the source potential factors by the sum of the transport potential factors and by the sum of the buffer/setback reduction factors.

P index = $\Sigma(\text{source potential factors}) \times \Sigma(\text{transport potential factors}) \times \Sigma(\text{buffer / setback reduction factors})$

$$\begin{aligned} & \text{_____} \Sigma(\text{P loss Source Potential Factors}) \\ \times & \text{_____} \Sigma(\text{P loss Transport Potential Factors}) \\ \times & \text{_____} \Sigma(\text{Buffer / Setback Reduction Factors}) \\ & = \text{_____} \text{P index Rating} \end{aligned}$$

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> 25	PI-4: very high potential for P movement from this site given current management practices and site characteristics. No P should be applied to this site. Active remediation techniques should be implemented in an effort to reduce the P loss potential from this site.

Nutrient accumulation and removal by crops commonly grown in South Carolina

Crop ¹	Crop Removal Rates (lbs./ac.) ^{2,3}			Application Recommendation ⁴
	N	P205	K2O	
Corn (80 bu/ac.) (grain)	60	35	23	100
Corn (100 bu/ac.) (grain)	75	44	29	120
Corn (130 bu/ac.) (grain)	98	57	38	150
Corn, Irr. (170 bu./ac) (grain)	128	75	51	200
Corn, sil. (11t/ac.) (35% w)	160	60	135	180
Cotton (1000 lbs. lint/ac.)	63	25	29	70
Fescue (hay) (3 tons/ac.)	116	56	159	150
Fescue (pasture)(per ton)	18	4.6	29	100 ⁵
Grain Sorghum (50 bu/ac.)	46	19.1	60	100
Sorghum. Sil. (7 t. DM/ac.)	66	22	63	120
Peanuts (3000 lbs/ac) ⁶	105	17	26	75
Peanuts w/vines rem.for hay ⁶	180	30	139	75
Small Grains (60 bu./ac)	80	34	20	80
Small Grains (hay or silage)	56	23.5	69	80
Soybeans (30 bu/ac.) ⁶	120	24	42	75
Bermuda/Bahia Pasture	43	12	64	150
Bermuda, Hybrid (6 ton./ac.)	300	84	252	400
Bermuda/Bahia Hay (4 tons/ac.)	105	14	112	240
Temporary Grazing (W or S)	50	16.5	58	60
Pine Trees ⁷	75	22	130	75

1 "Cool season perennial grass - legume pasture" is not on the list. If nitrogen containing fertilizers are applied to pastures with legumes, the grass typically out competes the legumes and eventually results in an all grass pasture. Thus, using the fescue pasture as representative of all cool season perennial pastures is recommended

2 The rates included as removal rates are based primarily on values compiled by Dr. Jim Camberato, Clemson University Cooperative Extension Service and the USDA Plants Database, Crop Nutrient Tool.

3 Additional information on crop removal of nutrients may be found in the "Crop Nutrient Tool" on the USDA Plants Database (<http://plants.usda.gov>). The nutrient removal database in AFO Pro includes some choices not included in the table above.

4 Nitrogen converts to the nitrate form rather quickly and nitrate rather leaches from the soil. Thus in our climate very little of the nitrogen would be in the root zone of the soil by the next crop period. Consequently, the total amount of N removal typically should reflect the recommended N application rates for crop production rather than the amount that would be removed by the crop actually be in the removed plant material.

5 Total recommendation per acre.

6 S.C. NRCS guides limit the application of animal waste on legumes to an amount that would provide no more than 75 lbs. of N. Consequently that amount is shown as the removal N removal rate for peanuts and soybeans. Legumes typically produce their own nitrogen. However, if nitrogen is applied they typically are somewhat lazy and utilize the supplemental nitrogen to the extent that it is applied rather than converting their own nitrogen.

7 The rates for pine trees were based information from "Forest Land Application of Animal Manures" by Dinkins, McKee and Camberato and "A Model for Soil Nutrient Uptake and Harvest removal in Loblolly Pine" North Carolina Forest Nutrition Cooperative, Department of Forestry, NCSU, 1997, based on agronomic rates. See notes below for information on actual removal.

- Estimated P₂O₅ that will accumulate in the wood and be removed with eventual timber harvest - 19 lbs. of P₂O₅/acre.
- Estimated annual accumulation in timber that will be harvested and in pine straw that is harvested annually -12 lbs. of P₂O₅/acre

Definitions

Before using the index, it is important to understand the *definition* of all factors:

Soil Erosion – annual sheet and rill erosion, determined by the Revised Universal Soil Loss Equation (RUSLE) and measured in tons soil loss/acre/year

Surface Runoff Factor – potential for water to leave the field from overland or surface flow; determined from slope and soil permeability class

Subsurface Drainage Factor – potential for water to move below ground in subsurface lateral flow; determined from depth to seasonal high water table, soil drainage class, and possible existence of artificial subsurface drainage

Distance from edge of field to surface water – distance (feet) from the edge of the cropped area to the nearest surface water. Surface water includes any permanent conduit for transporting surface water, including permanent streams and ditches that flow intermittently through the year. This category also includes the width of a permanent vegetated buffer strip and the possible inclusion of a “no P application zone” along the edge nearest water (a conservation practice to keep P away from the water).

Soil Test P – the relative amount of plant available P in the soil determined by a soil test and reported as lbs/acre using the Mehlich I analysis method.

P Fertilizer Application Rate – P_2O_5 lbs/A

P Fertilizer Application Method – injected, incorporated (including how long after application it was incorporated), surface applied (including date of surface application)

Organic P Application Rate – P_2O_5 lbs/A, dependant on P source

Organic P Application Method – injected, incorporated (including how long after application it was incorporated), surface applied (including date of surface application),

FOTG - USDA-NRCS, Field Office Technical Guide

Notes of Field Measurements

SLOPE:

STEEPNESS should be measured using a standard clinometer or abney level. This technique should not be attempted without guidance from a trained professional. Although not difficult, it takes some practice to learn how to take this measurement. It helps to have another person in the field at which to aim the clinometer.

LENGTH can be measured using a tape, or estimated by counting the number of steps it takes to walk the slope. An experienced professional can estimate by just looking at the slope. This is a difficult measurement and is usually variable when measured by two different people.

DISTANCE TO SURFACE WATER should be measured using a measuring tape. It is important to get an exact measurement as there is a big difference in the final outcome between ten and eleven feet. When looking at this distance, one must also note the existence of a vegetated buffer. Included in this category is the possibility of a “no P application zone.” This is simply an area next to any water which has no P applied. The existence and size of the “no P application zone” is not measured in the field, but it is determined by talking to the farm operator. It is a possible suggestion for a BMP that can be applied to reduce the P Index, especially if the P Index is in the high or very high range.

TILE DRAINAGE should be noted if it exists in any field, as it effects the subsurface drainage potential factor.

SPECIAL PRACTICES are also important to note, as these will affect the “P” factor in the RUSLE calculation. To determine the P factor, it is important to note hydrologic soil group, ridge height, furrow grade, and cover management condition (throughout the entire rotation).